EXHIBIT S7 TO DECLARATION OF STEPHEN G. SCHWARZ IN SUPPORT OF PLAINTIFFS' MOTION FOR CLASS CERTIFICATION

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Certified Mail

September 27, 2007

NO CBI

Document Processing Center
EPA East – Room 6428 Attn: Section 8(e)
Office of Pollution Prevention and Toxics
US EPA
1200 Pennsylvania Avenue NW
Washington DC 20460-0001

Re: TSCA 8(e) Substantial Risk Notice: Supplemental to Docket No. 8EHQ-0598-373; Sulfonate-based and Carboxylic-based Fluorochemicals

To whom it may concern:

3M is submitting this notice to supplement its previous submissions on sulfonate-based and carboxylic-based fluorochemicals. Enclosed is a final report detailing the results of a cohort mortality study of workers at the former 3M ammonium perfluorooctanoate (APFO) production facility in Cottage Grove, MN. While 3M does not believe that these data are reportable under the TSCA 8(e) reporting criteria, a decision was made to provide this report to the EPA, recognizing the ongoing work to assess fluorochemical exposure pathways and potential risks.

The purpose of cohort mortality study was to examine possible associations between working in jobs with varying exposure to APFO and specific causes of death. Conclusions of the authors were as follows:

> "APFO exposed workers did not have an elevated risk of death when compared to the population of the state of Minnesota, however, within the cohort risk of death from prostate cancer and cerebrovascular disease was elevated for workers with higher estimated exposure. Interpreting the somewhat contradictory results requires caution and consideration of several assumptions. *A priori* causes of death selected based on animal toxicology studies, liver, pancreatic and testicular cancer and cirrhosis of the liver, were not observed to be associated with APFO exposure."

If you have any questions, please contact Deanna Luebker at (651) 737-1374 or djluebker@mmm.com.

Sincerely,

Katherine E. Reed (DL)

Katherine E. Reed
Staff Vice President, Environmental, Health and Safety Operations

Enclosure

429.6 Rupture of papillary muscle

⑤ **429.7 Certain sequelae of myocardial infarction, not elsewhere classified**

Use additional code to identify the associated myocardial infarction:
with onset of 8 weeks or less (410.00-410.92)
with onset of more than 8 weeks (414.8)

Excludes: *congenital defects of heart (745, 746)*
coronary aneurysm (414.11)
disorders of papillary muscle (429.6, 429.81)
postmyocardial infarction syndrome (411.0)
rupture of chordae tendineae (429.5)

429.71 Acquired cardiac septal defect

Excludes: *acute septal infarction (410.00-410.92)*

429.79 Other
Mural thrombus (atrial) (ventricular), acquired, following myocardial infarction

⑤ **429.8 Other ill-defined heart diseases**

429.81 Other disorders of papillary muscle
Papillary muscle:
atrophy
degeneration
dysfunction
Papillary muscle:
incompetence
incoordination
scarring

429.82 Hyperkinetic heart disease

429.89 Other
Carditis

Excludes: *that due to hypertension (402.0-402.9)*

429.9 Heart disease, unspecified
Heart disease (organic) NOS
Morbus cordis NOS

Excludes: *that due to hypertension (402.0-402.9)*

CEREBROVASCULAR DISEASE (430-438)

Includes: with mention of hypertension (conditions classifiable to 401-405)
Use additional code, if desired, to identify presence of hypertension

Excludes: *any condition classifiable to 430-434, 436, 437 occurring during pregnancy, childbirth, or the puerperium, or specified as puerperal (674.0)*

430 Subarachnoid hemorrhage
Meningeal hemorrhage
Ruptured:
berry aneurysm
(congenital) cerebral aneurysm NOS

Excludes: *syphilitic ruptured cerebral aneurysm (094.87)*

431 Intracerebral hemorrhage
Hemorrhage (of):
basilar
bulbar
cerebellar
cerebral
cerebromeningeal
cortical
internal capsule
Hemorrhage (of):
intrapontine
pontine
subcortical
ventricular
Rupture of blood vessel in brain

432 Other and unspecified intracranial hemorrhage

432.0 Nontraumatic extradural hemorrhage
Nontraumatic epidural hemorrhage

432.1 Subdural hemorrhage
Subdural hematoma, nontraumatic

432.9 Unspecified intracranial hemorrhage
Intracranial hemorrhage NOS

⑤ **433 Occlusion and stenosis of**
The following fifth-digit sub
0 without mention o
1 with cerebral infa
Includes: embolism
narrowing
obstruction
thrombosis

Excludes: *insufficiency*

⑤ **433.0 Basilar artery**
⑤ **433.1 Carotid artery**
⑤ **433.2 Vertebral artery**
⑤ **433.3 Multiple and bilater**
⑤ **433.8 Other specified prec**
⑤ **433.9 Unspecified precerel**
Precerebral artery

⑤ **434 Occlusion of cerebral arter**
The following fifth-digit subc
0 without mention of
1 with cerebral infar
⑤ **434.0 Cerebral thrombosis**
Thrombosis of cerei
⑤ **434.1 Cerebral embolism**
⑤ **434.9 Cerebral artery occl**

435 Transient cerebral ischemia
Includes: cerebrovascula
symptoms
insufficiency o
spasm of cerel

Excludes: *acute cerebrov*
that due to an

435.0 Basilar artery syndr
435.1 Vertebral artery syn
435.2 Subclavian steal sync
435.3 Vertebrobasilar arter
435.8 Other specified trans
435.9 Unspecified transient
Impending cerebrov
Intermittent cerebral
Transient ischemic a

436 Acute, but ill-defined, cereb
Apoplexy, apoplectic
NOS
attack
cerebral
seizure

Excludes: *any condition*

437 Other and ill-defined cerebr
437.0 Cerebral atherosclerc
Atheroma of cerebra
Cerebral arteriosclerc
437.1 Other generalized isc
Acute cerebrovascul
Cerebral ischemia (c
437.2 Hypertensive encepha

● Code new to this edition ▲ Revision of existing code ④ ⑤ Fourth or fifth digit required

Add 4th or 5th digit

⑤ **433 Occlusion and stenosis of precerebral arteries**

The following fifth-digit subclassification is for use with category 433:

0 without mention of cerebral infarction

1 with cerebral infarction

Includes: embolism, narrowing, obstruction, thrombosis of basilar, carotid, and vertebral arteries

Excludes: insufficiency NOS of precerebral arteries (435.0-435.9)

⑤ **433.0 Basilar artery**

⑤ **433.1 Carotid artery**

⑤ **433.2 Vertebral artery**

⑤ **433.3 Multiple and bilateral**

⑤ **433.8 Other specified precerebral artery**

⑤ **433.9 Unspecified precerebral artery**
Precerebral artery NOS

⑤ **434 Occlusion of cerebral arteries**

The following fifth-digit subclassification is for use with category 434:

0 without mention of cerebral infarction

1 with cerebral infarction

⑤ **434.0 Cerebral thrombosis**
Thrombosis of cerebral arteries

⑤ **434.1 Cerebral embolism**

⑤ **434.9 Cerebral artery occlusion, unspecified**

435 Transient cerebral ischemia
Includes: cerebrovascular insufficiency (acute) with transient focal neurological signs and symptoms
insufficiency of basilar, carotid, and vertebral arteries
spasm of cerebral arteries

Excludes: acute cerebrovascular insufficiency NOS (437.1)
that due to any condition classifiable to 433 (433.0-433.9)

435.0 Basilar artery syndrome

435.1 Vertebral artery syndrome

435.2 Subclavian steal syndrome

435.3 Vertebrobasilar artery syndrome

435.8 Other specified transient cerebral ischemias

435.9 Unspecified transient cerebral ischemia
Impending cerebrovascular accident
Intermittent cerebral ischemia
Transient ischemic attack [TIA]

436 Acute, but ill-defined, cerebrovascular disease
Apoplexy, apoplectic: NOS, attack, cerebral, seizure
Cerebral seizure
Cerebrovascular accident [CVA] NOS
Stroke

Excludes: any condition classifiable to categories 430-435

437 Other and ill-defined cerebrovascular disease

437.0 Cerebral atherosclerosis
Atheroma of cerebral arteries
Cerebral arteriosclerosis

437.1 Other generalized ischemic cerebrovascular disease
Acute cerebrovascular insufficiency NOS
Cerebral ischemia (chronic)

437.2 Hypertensive encephalopathy

437.3 Cerebral aneurysm, nonruptured
Internal carotid artery, intracranial portion
Internal carotid artery NOS

Excludes: *congenital cerebral aneurysm, nonruptured (747.81)*
internal carotid artery, extracranial portion (442.81)

437.4 Cerebral arteritis

437.5 Moyamoya disease

437.6 Nonpyogenic thrombosis of intracranial venous sinus

Excludes: *pyogenic (325)*

437.7 Transient global amnesia

437.8 Other

437.9 Unspecified
Cerebrovascular disease or lesion NOS

438 Late effects of cerebrovascular disease

Note: This category is to be used to indicate conditions in 430-437 as the cause of late effects. The "late effects" include conditions specified as such, as sequelae, which may occur at any time after the onset of the causal condition.

438.0 Cognitive deficits

⑤ **438.1 Speech and language deficits**

438.10 Speech and language deficit, unspecified

438.11 Aphasia

438.12 Dysphasia

438.19 Other speech and language deficits

⑤ **438.2 Hemiplegia/hemiparesis**

438.20 Hemiplegia affecting unspecified side

438.21 Hemiplegia affecting dominant side

438.22 Hemiplegia affecting nondominant side

⑤ **438.3 Monoplegia of upper limb**

438.30 Monoplegia of upper limb affecting unspecified side

438.31 Monoplegia of upper limb affecting dominant side

438.32 Monoplegia of upper limb affecting nondominant side

⑤ **438.4 Monoplegia of lower limb**

438.40 Monoplegia of lower limb affecting unspecified side

438.41 Monoplegia of lower limb affecting dominant side

438.42 Monoplegia of lower limb affecting nondominant side

⑤ **438.5 Other paralytic syndrome**

Use additional code to identify type of paralytic syndrome, such as:
locked-in state (344.81)
quadriplegia (344.00-344.09)

Excludes: *late effects of cerebrovascular accident with:*
hemiplegia/hemiparesis (438.20-438.22)
monoplegia of lower limb (438.40-438.42)
monoplegia of upper limb (438.30-438.32)

438.50 Other paralytic syndrome affecting unspecified side

438.51 Other paralytic syndrome affecting dominant side

438.52 Other paralytic syndrome affecting nondominant side

438.53 Other paralytic syndrome, bilateral

⑤ **438.8 Other late effects of cerebrovascular disease**

438.81 Apraxia

438.82 Dysphagia

438.89 Other late effects of cerebrovascular disease
Use additional code to identify the late effect

438.9 Unspecified late effects of cerebrovascular disease

440 Atherosclerosis
Includes: arteriolosclerosis
arteriosclerosis (
arteriosclerotic v
atheroma
degeneration:
arterial
arteriovascular
vascular
endarteritis defo
senile arteritis
senile endarteriti

Excludes: *atherosclerosis (*

440.0 Of aorta

440.1 Of renal artery

Excludes: *atherosclerosis (*

⑤ **440.2 Of native arteries of t**

Excludes: *atherosclerosis (*

440.20 Atherosclerosis

440.21 Atherosclerosis

440.22 Atherosclerosis
Includes: any

440.23 Atherosclerosis
Includes: any
Use addition

440.24 Atherosclerosis
Includes: any
with ischem

Excludes: *gas gangrene (0*

440.29 Other

⑤ **440.3 Of bypass graft of the**

Excludes: *atherosclerosis*
embolism [occlu
of graft (996.74

440.30 Of unspecifie

440.31 Of autologou

440.32 Of nonautolo

440.8 Of other specified art

Excludes: *basilar (433.0)*
carotid (433.1)
cerebral (437.0
coronary (414.0
mesenteric (557
precerebral (43
pulmonary (416
vertebral (433.2

440.9 Generalized and unsp
Arteriosclerotic vascu

Excludes: *arteriosclerotic*

441 Aortic aneurysm and dissec

Excludes: *syphilitic aortic*
traumatic aorti

⑤ **441.0 Dissection of aorta**
Dissecting aneurysm

441.00 Unspecified

441.01 Thoracic

441.02 Abdominal

747.41 Total anomalous pulmonary venous connection
Total anomalous pulmonary venous return [TAPVR]:
subdiaphragmatic
supradiaphragmatic

747.42 Partial anomalous pulmonary venous connection
Partial anomalous pulmonary venous return

747.49 Other anomalies of great veins
Absence, Congenital stenosis } of vena cava (inferior) (superior)
Persistent:
left posterior cardinal vein
left superior vena cava
Scimitar syndrome
Transposition of pulmonary veins NOS

747.5 Absence or hypoplasia of umbilical artery
Single umbilical artery

⑤ **747.6 Other anomalies of peripheral vascular system**
Absence, Anomaly, Atresia } of artery or vein, not elsewhere classified
Arteriovenous aneurysm (peripheral)
Arteriovenous malformation of the peripheral vascular system
Congenital:
aneurysm (peripheral)
phlebectasia
stricture, artery
varix
Multiple renal arteries

Excludes: *anomalies of:*
cerebral vessels (747.81)
pulmonary artery (747.3)
congenital retinal aneurysm (743.58)
hemangioma (228.00-228.09)
lymphangioma (228.1)

747.60 Anomaly of the peripheral vascular system, unspecified site

747.61 Gastrointestinal vessel anomaly

747.62 Renal vessel anomaly

747.63 Upper limb vessel anomaly

747.64 Lower limb vessel anomaly

747.69 Anomalies of other specified sites of peripheral vascular system

⑤ **747.8 Other specified anomalies of circulatory system**

747.81 Anomalies of cerebrovascular system
Arteriovenous malformation of brain
Cerebral arteriovenous aneurysm, congenital
Congenital anomalies of cerebral vessels

Excludes: *ruptured cerebral (arteriovenous) aneurysm (430)*

747.82 Spinal vessel anomaly
Arteriovenous malformation of spinal vessel

747.89 Other
Aneurysm, congenital, specified site not elsewhere classified

Excludes: *congenital aneurysm:*
coronary (746.85)
peripheral (747.6)
pulmonary (747.3)
retinal (743.58)

747.9 Unspecified anomaly of circulatory system

748 Congenital anomalies of respiratory system

Excludes: *congenital defect of diaphragm (756.6)*

748.0 Choanal atresia
Atresia, Congenital stenosis } of nares (anterior) (posterior)

748.1 Other anomalies of nose
Absent nose C
Accessory nose
Cleft nose
Deformity of wall of nasal sinus

Excludes: *congenital deviation of nasal*

748.2 Web of larynx
Web of larynx:
NOS
glottic
subglottic

748.3 Other anomalies of larynx, trache
Absence or agenesis of: C
bronchus
larynx
trachea
Anomaly (of):
cricoid cartilage
epiglottis D
thyroid cartilage
tracheal cartilage
Atresia (of): F
epiglottis L
glottis P
larynx R
trachea S
Cleft thyroid, cartilage, congenital

748.4 Congenital cystic lung
Disease, lung: F
cystic, congenital
polycystic, congenital

Excludes: *acquired or unspecified cyst*

748.5 Agenesis, hypoplasia, and dysplas
Absence of lung (fissures) (lobe)
Aplasia of lung
Hypoplasia of lung (lobe)
Sequestration of lung

⑤ **748.6 Other anomalies of lung**

748.60 Anomaly of lung, unspec

748.61 Congenital bronchiectasi

748.69 Other
Accessory lung (lobe)
Azygos lobe (fissure), lu

748.8 Other specified anomalies of resp
Abnormal communication betwee
Anomaly, pleural folds
Atresia of nasopharynx
Congenital cyst of mediastinum

748.9 Unspecified anomaly of respirato
Anomaly of respiratory system N

749 Cleft palate and cleft lip

⑤ **749.0 Cleft palate**

749.00 Cleft palate, unspecified

749.01 Unilateral, complete

749.02 Unilateral, incomplete
Cleft uvula

749.03 Bilateral, complete

749.04 Bilateral, incomplete

⑤ **749.1 Cleft lip**
Cheiloschisis
Congenital fissure of lip

441.03 **Thoracoabdominal**

441.1 **Thoracic aneurysm, ruptured**

441.2 **Thoracic aneurysm without mention of rupture**

441.3 **Abdominal aneurysm, ruptured**

441.4 **Abdominal aneurysm without mention of rupture**

441.5 **Aortic aneurysm of unspecified site, ruptured**
Rupture of aorta NOS

441.6 **Thoracoabdominal aneurysm, ruptured**

441.7 **Thoracoabdominal aneurysm, without mention of rupture**

441.9 **Aortic aneurysm of unspecified site without mention of rupture**
Aneurysm
Dilatation
Hyaline necrosis } of aorta

442 **Other aneurysm**
Includes: aneurysm (ruptured) (cirsoid) (false) (varicose)
aneurysmal varix
Excludes: *arteriovenous aneurysm or fistula:*
acquired (447.0)
congenital (747.60-747.69)
traumatic (900.0-904.9)

442.0 **Of artery of upper extremity**

442.1 **Of renal artery**

442.2 **Of iliac artery**

442.3 **Of artery of lower extremity**
Aneurysm:
femoral
popliteal } artery

⑤ 442.8 **Of other specified artery**

442.81 **Artery of neck**
Aneurysm of carotid artery (common) (external) (internal, extracranial portion)
Excludes: *internal carotid artery, intracranial portion (437.3)*

442.82 **Subclavian artery**

442.83 **Splenic artery**

442.84 **Other visceral artery**
Aneurysm:
celiac
gastroduodenal
gastroepiploic
hepatic
pancreaticoduodenal
superior mesenteric } artery

442.89 **Other**
Aneurysm:
mediastinal
spinal } artery
Excludes: *cerebral (nonruptured) (437.3)*
congenital (747.81)
ruptured (430)
coronary (414.11)
heart (414.10)
pulmonary (417.1)

442.9 **Of unspecified site**

443 **Other peripheral vascular disease**

443.0 **Raynaud's syndrome**
Raynaud's:
disease
phenomenon (secondary)
Use additional code, if desired, to identify gangrene (785.4)

443.1 **Thromboangiitis obliterans [Buerger's disease]**
Presenile gangrene

⑤ 443.8 **Other specified peripheral vascular**

443.81 *Peripheral angiopathy in d*
Code first underlying dise
diabetes mellitus (250.7)

443.89 **Other**
Acrocyanosis
Acroparesthesia:
simple [Schultze's type]
vasomotor [Nothnagel's
Erythrocyanosis
Erythromelalgia
Excludes: *chilblains (991.5)*
frostbite (991.0-991.3)
immersion foot (991.4)

443.9 **Peripheral vascular disease, unspec**
Intermittent claudication NOS
Peripheral:
angiopathy NOS
vascular disease NOS
Spasm of artery
Excludes: *atherosclerosis of the arteries*
spasm of cerebral artery (435.

444 **Arterial embolism and thrombosis**
Includes: infarction:
embolic
thrombotic
occlusion
Excludes: *that complicating:*
abortion (634-638 with .6, 6
ectopic or molar pregnancy (
pregnancy, childbirth, or the

444.0 **Of abdominal aorta**
Aortic bifurcation syndrome Leri
Aortoiliac obstruction Sad

444.1 **Of thoracic aorta**
Embolism or thrombosis of aorta (th

⑤ 444.2 **Of arteries of the extremities**

444.21 **Upper extremity**

444.22 **Lower extremity**
Arterial embolism or thromb
femoral
peripheral NOS
popliteal
Excludes: *iliofemoral (444.81)*

⑤ 444.8 **Of other specified artery**

444.81 **Iliac artery**

444.89 **Other**
Excludes: *basilar (433.0)*
carotid (433.1)
cerebral (434.0-434.9)
coronary (410.00-410.92)
mesenteric (557.0)
ophthalmic (362.30-362.34)
precerebral (433.0-433.9)
pulmonary (415.19)
renal (593.81)
retinal (362.30-362.34)
vertebral (433.2)

444.9 **Of unspecified artery**

446 **Polyarteritis nodosa and allied conditions**

Final Report

Mortality Study of Workers Employed at the 3M Cottage Grove Facility

Submitted by:

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April 26, 2001

Summary

Objective:

To determine whether occupational exposure to perfluorooctanoic acid (PFOA) and other fluorochemicals is related to the mortality experience of employees of the 3M facility in Cottage Grove, Minnesota.

Methods

All employees who accrued at least one year of employment at Cottage Grove were eligible for inclusion in the study. Cohort members were assigned to one of three exposure groups based on their work history: non-exposed, probable exposure to PFOA, and definite exposure to PFOA. The cohort was followed through December 31, 1997. Death certificates were obtained for all known deaths and coded for analysis. Standardized mortality ratios were estimated for all cause and cause specific mortality using mortality rates from the general population of Minnesota as a reference. SMR estimates were made for the sub-cohorts ever exposed to PFOA, by exposure category, and for a minimum of one year of exposure.

Results

There were 3,992 eligible cohort members who accrued 108,198 person-years of follow-up and 607 deaths. Forty-six of the deaths occurred in the sub-cohort with definite PFOA exposure. The all cause and all cancer mortality rates for the entire study population, and for the exposure sub-cohorts were less than expected in the general population. There was no association between exposure to PFOA or other fluorochemicals and cancer of the liver, kidney, or prostate or cirrhosis of the liver. A modest increased risk of death from cerebrovascular disease (CVD) was observed in the definite PFOA exposure subcohort the (5 observed, 1.94 expected, SMR=2.58, 95% CI=0.84-6.03). A dose response relationship between PFOA or other fluorochemical exposure and CVD was not apparent.

Conclusion

Employees of the Cottage Grove facility were not observed to have an excess risk of mortality from cancer in relation to PFOA and other fluorochemical exposure. The association observed between PFOA exposure and CVD was modest, but unexpected. The association may be due to some occupational exposure although there is no biologically plausible mechanism identified at this time.

Introduction

The Cottage Grove manufacturing facility of the Minnesota Mining and Manufacutring Corporation (3M) has produced perfluoroinated compounds since 1947. A primary product from this plant is ammonium perfluorooctanoate ($CF_3(CF_2)_6CO_2NH_4^+$, APFO), a potent synthetic surfactant used in industrial applications. APFO rapidly dissociates in biologic media to perfluorooctanoate ($CF_3(CF_2)_6CO_2^-$, PFOA) which is the anion of perfluorooctanoic acid ($CF_3(CF_2)_6COOH$). In laboratory animals, PFOA and its salts are: 1) absorbed by ingestion, inhalation or dermal contact; [1-3] 2) distributed primarily in the liver and blood;[4] 3) not biotransformed, conjugated or incorporated into lipids;[5,6] and 4) eliminated in the female rat at a greater rate of excretion than the male rat.[7] In rats, administration of APFO resulted in peroxisome proliferation, uncoupling of mitochondrial oxidative phosphorylation and altered lipid metabolism.[8,9] In lifetime feeding bioassays of rats, APFO in the diet at 300 ppm (daily dose of 15 mg/kg/day) increased the incidence of liver Leydig cell and pancreas acinar cell adenomas.[10] The liver tumors most likely occurred via the nongenotoxic mechanisms of oxidative stress and apoptosis. Increased hepatic aromatase activity may have resulted in a hormone-mediated mechanism (increased estradiol) for the formation of the Leydig cell tumors.[11,12] The pancreas acinar cell adenomas have been hypothesized to be a result of a mild but sustained increase in cholecystokin (CCK) levels secondary to hepatic cholestasis.[13] In a 90-day gavage study of rhesus monkeys, mortality was pronounced prior to end of study in the 100 mg/kg/day and 30 mg/kg/day dose groups.[14] Histopathologic examination revealed marked diffuse lipid depletion in the adrenals, slight to moderate hypocelluarity of bone marrow and moderate atrophy of lymphoid follicles. No histopathologic changes were reported in the 3 and 10 mg/kg/day dose groups. A recently completed 6-month gavage study of cynomolgus primates demonstrated a steep dose response curve.[15] Both the low (3 mg/kg/day) and mid (10 mg/kg/day)

dose groups resulted solely in increased liver weights. The highest dose group (30/20 kg/mg/day) resulted in severe toxicity, which required the removal of treatment for some of the high dose group animals. The exact mechanism of toxicity in the primate remains to be elucidated.

Hepatic toxicity, hypolipidemia and abnormal hormone levels (e.g., estradiol) have not been associated with the PFOA levels measured in male APFO production workers.[16-20] However, it should be noted that the serum concentration (50 ppm) associated with liver enlargement in the 3.0 mg/kg/day dose group of the cynomolgus primate study is within the range experienced by workers with higher occupational exposure.[15,19,20] A retrospective cohort mortality study of workers engaged in APFO production at the Cottage Grove facility found no significantly increased cause-specific standardized mortality ratio although a two-fold nonsignfiicant increase in prostate cancer mortality, based on 4 observed deaths was reported.[21] This report summarizes the results of an update of that cohort mortality study with a specific emphasis on exposure to PFOA.

Methods

Cohort Enumeration

The cohort for this study was enumerated using employment records from the Cottage Grove facility. Workers accruing at least 1 year of cumulative employment at the Cottage Grove facility as of December 31, 1997 were eligible for inclusion in the cohort. A review of employee work history records by 3M personnel identified workers eligible for the cohort. The records of any Cottage Grove employee with at least one year of cumulative employment were abstracted to record the worker's name, Social Security Number, 3M identification number, date of birth, and the dates of any entry on the work history record, including layoffs and leaves of absence.

Information about each job was abstracted wherever available, including the department codes, and job classifications. The names, Social Security Numbers, 3M identification numbers, and dates of birth were recorded for workers with less than one year of cumulative employment for comparison with the original cohort. The abstracted data were entered into a computer database and provided to University of Minnesota investigators.

The newly enumerated cohort was linked to records from the original cohort to update the employment information and verify names, Social Security Numbers dates of birth and dates of death. Discrepancies identified in the records were resolved using TRW/Experian, a credit reporting agency, and the Social Security Administration service for epidemiologic research studies. The latter reports the most recent account activity of an individual and whether they are recorded as deceased in the Social Security Death Index (SSDI). Duplicate records due to name changes or incorrect data were eliminated.

Investigators at the University of Minnesota reviewed the eligibility for inclusion in the cohort. To be eligible for the cohort a worker had to accrue at least 365 days of cumulative employment at the Cottage Grove site. The eligibility of each cohort member was determined by summing his or her dates of employment, exclusive of periods of absence due to illness, military leave, maternity leave, or layoff. Currently employed workers were assigned December 31, 1997 as their last date of employment.

Follow-up and Determination of Vital Status

Eligible cohort members were followed from the day they accrued 365 days of cumulative employment till December 31, 1997 or their date of death. Vital records searches were performed for all cohort members not employed by 3M on December 31, 1997, or for whom a death certificate was not obtained in the original study. The National Death Index (NDI) was searched for all workers in the original study and new workers included in the cohort. The Social Security Administration data and/or the SSDI were searched to verify the vital status of workers who terminated employment before 1979.

The records of cohort members identified as deceased through the NDI or SSDI were reviewed by hand to ensure a valid match and a copy of the death certificate was requested from the state of record. A licensed nosologist coded the death certificates to the International Classification of Disease Version 8. A second licensed nosologist coded the death certificate using the rules for the ICD version in effect at the time of death. This second coding was used for verification and enabled the use of actual (unadjusted) mortality reference data.

Exposure Assessment

The goal of this study was to describe mortality experience in relation to fluorochemical exposure. Of particular interest was exposure to PFOA. The areas in the Cottage Grove facility where PFOA and other fluorochemicals were produced changed over the years. Because the department codes used to classify the work areas also changed over years it was not possible to assign the workers to exposure categories on work history information alone. To ascertain exposure status the department codes were reviewed to determine the building and division

assigned to each code. These lists were then reviewed independently by a panel of veteran workers and plant industrial hygienists to determine where fluorochemical production or the development of fluorochemical products took place throughout the history of the Cottage Grove Facility. The responses of the individual reviews were summarized and the panel was convened as a group to discuss the exposure assignments. The available information limited the panel's ability to classify each department with certainty, thus general classifications of exposure were adopted. The job history information was classified into the three following groups;

- Definite PFOA exposure (potentially high). These jobs included workers employed in the areas where cell generation, drying, shipping, and packaging of PFOA occurred throughout the history of the plant.
- Probable PFOA exposure. These jobs include other chemical division jobs where exposure to PFOA was possible, but with lower or transient exposures.
- Not exposed to fluorochemicals. Primarily non-chemical division jobs.

Hereafter these exposure subgroups will be referred to as definite exposure, probable exposure and nonexposed, respectively.

Potential for exposure to other fluorochemcials was possible in the chemical division. In particular, there has been production of some salts of perfluorooctane sulfonic acid, which may disassociate to perfluoroctanesulfonate (PFOS, $C_8F_{17}SO_3^-$). However, this did not usually occur where definite PFOA exposure in the workplace was likely, as the production areas were in different buildings. It is feasible that employees who had worked in jobs with definite PFOA exposure may have transferred to this other building in the course of their career.

Analysis

The mortality experience of the Cottage Grove cohort was compared to that of the general population of the state of Minnesota. Mortality reference rates from seven regional counties (Hennepin, Ramsey, Anoka, Carver, Dakota, Scott, and Washington) were also used to rule out large variations based on regional mortality reporting differences. Reference data were obtained from the Mortality Population Data System (MPDS) center at the University of Pittsburgh. These data are derived from National Center for Health Statistics data and provide all cause mortality and malignant neoplasm rates back to 1940, and non-malignant cause specific death rates from 1962 forward. These reference data are age (5 year), gender, race, and calendar period (5 year) specific and are coded using the rules for the ICD version in effect for the calendar period.

Standardized mortality ratios (SMR) were computed for all cause and cause specific deaths using the Minnesota reference data. The expected number of deaths for all cause and malignant neoplasm deaths were estimated for all years. The expected number of deaths from non-malignant causes was computed for the years 1962-1997. Observed deaths and person-years in the denominator occurring before the reference data were available were excluded from the analysis. The SMRs and appropriate 95% confidence intervals were computed using the PC Life Table Analysis System (PCLTAS) software developed by the National Institutes of Occupational Safety and Health (NIOSH).[22] This program computes age, gender, and race specific SMR using standard life table methods. The expected number of deaths are estimated by multiplying the age, gender, race, and calendar period tabulated person-years of follow-up to the corresponding cause specific mortality reference rates. No data on race were available for the cohort; therefore, the reference data were limited to the mortality rates for white Minnesotans.

The all cause and cause specific SMRs were initially computed for the entire cohort and the subcohorts with definite exposure, probable exposure, and not exposed to fluorochemicals. A more exposure specific analysis stratified workers based on a one-year minimum employment in jobs with definite PFOA exposure and definite or probable exposure. The latter included workers who accrued one year of employment with a combination of definite and probable exposed jobs.

Four causes of death potentially related to PFOA exposure based on laboratory animal data and the earlier cohort study, prostate cancer, liver cancer, kidney cancer, and cirrhosis of the liver, were analyzed by duration of exposure in each fluorochemical exposure subgroup. Other causes of death that appeared to be in excess in one or more of the fluorochemical exposed groups were also evaluated by duration of exposure.

Results

Of the 6678 individual workers identified at the Cottage Grove plant, 3992 employees met the one year inclusion criteria. Of these, 12 percent (492) worked at least one day in areas where definite exposure to PFOA occurred. Forty-two percent (1685) had probable exposure, but not definite PFOA exposure, and the remaining 45% (1815) were not exposed to fluorochemicals (Table 1). The latter are non-chemical division jobs at Cottage Grove. Male workers made up 80% of the cohort, but were 92% of the PFOA exposed cohort. The average age at follow up was slightly less in the PFOA exposed cohort, but the average duration of employment at Cottage Grove was slightly longer. There were 607 deaths identified in the cohort, 46 deaths in the definite PFOA exposure group and 267 in the probable PFOA exposure group. Death certificates were obtained for 590 of the decedents (97%). Six of the missing death certificates were in the probable PFOA exposure group and the rest were in the non-exposed group. More extensive exposure to PFOA, based on a one-year minimum employment in definitely exposed jobs, occurred to 182 workers (17 deaths), and 1673 workers had definite or probable exposure for at least one year (219 deaths) (Table 2).

The all cause and cause specific mortality rates for the entire cohort were lower than expected compared to the general population: 607 observed and 715 expected (SMR=0.85, 95% CI=0.78-0.92) (Table 3). A similar pattern was observed for all deaths from cancer; 172 observed, 204 expected (SMR=0.84, 95% CI = 0.72-0.98). Deaths from all causes and all cancers were fewer than expected for the exposure subcohorts (Table 4-6), and for the strata limited to workers with a minimum of one year of definite exposure (Table 7), or a combination of definite or probable exposure (Table 8).

There was no association observed between fluorochemical exposure and cancer of the prostate, liver, kidney, or from cirrhosis of the liver (Table 4-8). In the definite PFOA exposure subcohort only one death from prostate cancer was observed (0.77 expected). Five deaths from prostate cancer were observed in the probable PFOA exposure group (5.8 expected), and another 2 observed in the non-exposed sub-cohort (6.8 expected). Only one cancer of the liver was observed and that was in the probable PFOA exposure group. Again, limiting the cohort to a minimum of one year of exposure did not alter the results.

Overall, nonmalignant causes of death did not exceed that expected in Minnesota. Deaths from cerebrovascular disease (CVD) did exceed the number of expected in the definite PFOA exposed cohort; 5 observed and 1.94 expected (SMR=2.58, 95% CI 0.84-6.03). Deaths from CVD were not elevated in the rest of the cohort. Three CVD deaths occurred in the subcohort with definite exposure for at least one year, where 0.89 deaths were expected (SMR=3.36, 95% CI=0.69, 9.82). It is plausible that the coding of CVD deaths varies by region, where a CVD death in an older person may be reported as "Natural Causes" on the death certificate, which would receive a different ICD code. To verify these results the CVD deaths were compared to the local county mortality rates. The results were essentially the same.

To further evaluate the distribution of CVD deaths, the SMRs in the definite PFOA exposure sub-cohort were stratified by duration of employment in PFOA exposed jobs (Table 9), and exposure weighted time of employment (Table 10). In the exposure-weighted time of employment weights of 0, 1 and 3 were assigned respectively to the non-exposed, probable

PFOA exposed, and definite PFOA exposed jobs in the work histories. The weighted time of exposure was derived by multiplying the duration of employment in the exposed jobs, in days, by the weighting factor. The results for the years of employment in PFOA exposed jobs did not reveal a dose-response relationship between PFOA exposure and the risk of CVD; however, the SMR for high PFOA exposure for five or more years was 6.9 (95% CI = 1.39-20.24). This, however, was based on only three cases, and no deaths from CVD occurred among workers with ten or more years in high PFOA jobs (Table 9). The weighted exposure analysis, which includes information from the workers with probable exposure to PFOA indicated that the fluorochemical exposed workers with less than 10,000 exposure days experienced fewer than expected deaths from CVD. The SMR for those with 10,000 or more exposure days was 3.32 (95% CI=0.89-8.49). An exposure days value of 10,000 equates to 27 years of exposure in probable PFOA exposed jobs or 9 years in definite PFOA exposed jobs.

The number of deaths from traumatic injuries was less than expected for the entire cohort, however, the frequency of deaths from violence was modestly elevated in the definite exposure cohort. Five of the six violent deaths were suicides (2.1 expected, SMR 2.33, 95% CI=0.76-5.45) (Table 4).

Discussion

This updated mortality study evaluated the mortality experience of workers with at least one year of employment at the 3M Cottage Grove facility, with specific attention to exposure to PFOA. No excess mortality was observed for malignant neoplasms or for all causes of death. There were modest elevations in the risk of death from cerebrovascular disease and deaths due to violence in the higher PFOA exposed workers, but these results are based on very few cases.

Some limitations must be considered when interpreting the results of this mortality analysis. Although several methods of follow-up were employed to ascertain deaths in this cohort, the possibility remains that some deaths were not accounted for in the analysis. A death certificate was not obtained for seventeen known decedents; thus they were not included in the cause specific death analysis. The extent to which these limitations would affect the results is unknown, however most of the missing death certificates were in the nonexposed sub-cohort. Another limitation of this study is the lack of employee specific exposure data for PFOA and other fluorochemicals. The determination of potential exposure to these compounds was made using all available information from work histories and expert input from veteran workers and plant industrial hygienists. Nevertheless, some misclassification of exposure was likely. Maintenance and other mobile workers not specifically identified as definitely PFOA exposed workers may have routinely entered the PFOA exposed sites, and a few workers assigned to the PFOA exposure areas may not have spent much time in those areas. The extent to which this misclassification occurred and the attendant effects on the study results remain unknown.

This study differs from the analysis published by Gilliland and Mandel[21] by the study inclusion criteria and the exposure definition. The earlier study required six months of cumulative

employment for inclusion, while the current study required one year. The change was made primarily to exclude the relatively large number of short-term workers. Workers who left after only six months on the job were likely to have different underlying risk factors than the long-term workers. The Gilliland and Mandel analysis limited the exposure assignment to Chemical Division/Non-Chemical Division and assumed duration of employment in the chemical division equated with exposure to PFOA. The current analysis was driven by more recent toxicological evaluations of the compound, and specifically categorizes PFOA exposure as definite and probable within the Chemical Division as only certain areas and tasks within the Chemical Division would have led to high exposure to PFOA. . Another difference of note between the two analyses is the inclusion of 169 additional cohort members in the current study that, according to available employment data, were eligible for both studies.

The two analyses of this cohort differ by the results for prostate cancer and cerebrovascular disease. The previous analysis identified 6 cases of prostate cancer, four of which were in the Chemical Division. The current analysis identified eight cases of prostate cancer; one in the definite PFOA exposure group and five in the probable PFOA exposure group. In neither of the exposure groups did the number of prostate cancer deaths exceed the expected number. One case of prostate cancer identified in the previous study was not included in the current analysis because the worker did not meet the one-year minimum employment criteria.

Although Gilliland and Mandel considered an association between PFOA exposure and prostate cancer as biologically plausible based on the animal and human data,[17,21] subsequent research,[19]

as well as the present study findings would argue that, at this time, there is not an association observed in this workforce.

The result for cerebrovascular disease is difficult to interpret. There were 13 CVD deaths in the previous analysis and 26 in the current study. There was no excess of CVD deaths in the non-exposed group or the probable PFOA exposure group. In fact the SMRs were well below 1.0. There was not an apparent dose-response relationship, however such an analysis was hampered by the relatively few cases available to analyze. The lack of an association in the probable-PFOA exposure group and the absence of a change by using the local counties as a reference suggest that this is not an artifact of death certificate coding. CVD may be related to life style factors including smoking. It is noteworthy that the SMRs for all heart disease (1.08) and lung cancer (1.17) were at or above unity in the PFOA exposed sub-cohort. These diseases may be markers for smoking related illness. Heart disease and CVD are almost always below unity in epidemiologic studies of chemical workers. Therefore, these SMRs reported in the definite PFOA exposure group are unexpected. The observed association may be due to some occupational exposure at the Cottage Grove facility, although there is no biologically plausible mechanism identified. At this time a causal association cannot be drawn between exposure to PFOA and death from cerebrovascular disease.

The absence of measurable adverse health effects from PFOA exposure was also reported in earlier studies on this population. PFOA exposure did not alter circulating levels of reproductive hormones [19] and a study of the effects of PFOA on markers of liver function did not detect frank hepatotoxic effect.[18,20]

Recommendations

There does not appear to be a clear association between employment at the Cottage Grove plant and risk of mortality from cancer or other causes. However, due to the previous observation of an association with prostate cancer, the apparent excess occurrence of death from cerebrovascular disease, and the evolving understanding of the toxicology of PFOA, continued mortality follow-up of this cohort is warranted.

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Table 1. Characteristics of 3M employees with one or more years of employment at Cottage Grove.

	Definite PFOA exposure[a]	Probable PFOA Exposure[b]	Non-exposed[c]	Total
Total	492	1685	1815	3992
Gender				
M	452 (92%)	1387 (83%)	1344 (74%)	3183 (80%)
F	40 (8%)	298 (17%)	471 (26%)	809 (20%)
Mean age at follow-up	52.0	57.4	57.0	56.6
Median age at follow-up	50.6	57.8	57.6	57.0
Mean year at birth	1944	1938	1938	1938
Median year at birth	1946	1938	1938	1939
Mean years at CG	16.6	14.5	8.6	12.1
Median years at CG	14.2	10.7	4.5	7.2
Person years of follow-up	10703	44295	49188	108198
Deaths	46	267	294	607

a: Ever employed in job with definite (high) PFOA exposure
b: Ever employed in a job with probable to other fluorochemicals including low PFOA exposure, but never in a job with definite exposure.
c: Primarily non-Chemical Division.

Table 2. Characteristics of Cottage Grove workers with definite PFOA exposure and definite or probable PFOA exposure for a minimum of one year.

	Definite PFOA exposure[a]	Definite or Probable PFOA exposure[b]
Total	182	1673
Deaths	17	219
Person years	3897	41487
Gender		
M	168 (92%)	1442 (86%)
F	14 (8%)	231 (14%)
Mean age at follow-up	53	56
Mean year of birth	1943	1940
Mean years at Cottage Grove	17.8	15.7
Mean years of exposure	6.2	9.4

a: Definite (high) PFOA exposure for at least one year.

b: Definite or Probable PFOA or other fluorochemical exposure for at least one year. Includes workers who accrued one year of exposure with definite and probable jobs combined

Table 3. Cause specific deaths and standardized mortality ratios for selected causes of death for all Cottage Grove employees.

Cause	Observed	Expected	SMR	95% CI
All Deaths	607	715.13	0.85	0.78-0.92
Cancers				
All Malignant Neoplasms	172	203.96	0.84	0.72-0.98
Buccal Cavity and Pharynx	2	4.16	0.48	0.06-1.74
Digestive Organs and Peritoneum	42	50.38	0.83	0.60-1.13
Esophagus	3	5.34	0.56	0.12-1.64
Stomach	4	6.31	0.63	0.17-1.62
Large Intestine	19	18.18	1.04	0.63-1.63
Rectum	2	3.93	0.51	0.06-1.84
Biliary Passages and Liver Primary	1	4.43	0.23	0.01-1.25
Pancreas	12	10.78	1.11	0.57-1.94
All Other Digestive	1	1.40	0.71	0.02-3.97
Respiratory System	56	61.44	0.91	0.69-1.18
Larynx	2	1.80	1.11	0.13-4.02
Bronchus, Trachea, Lung	53	58.97	0.90	0.67-1.18
Breast	6	8.60	0.70	0.25-1.52
Female Reproductive	3	5.23	0.57	0.12-1.68
Male Reproductive	9	14.27	0.63	0.29-1.20
Prostate	8	13.41	0.60	0.26-1.18
Testis and Other Male Genital Organs	1	0.86	1.16	0.03-6.47
Urinary Organs	8	9.89	0.81	0.35-1.59
Kidney	3	6.06	0.49	0.10-1.45
Bladder and Other Urinary Organs	5	3.83	1.31	0.42-3.05
Malignant Melanoma of Skin	4	3.24	1.24	0.34-3.16
All Lymphatic and Hematopoietic Tissue	18	23.47	0.77	0.45-1.21
Non-malignant causes				
Cerebrovascular Disease	26	35.91	0.72	0.47-1.06
All Heart Disease	195	234.49	0.83	0.72-0.96
Nonmalignant Respiratory Disease	29	45.92	0.63	0.42-0.91
Cirrhosis of Liver	11	14.33	0.77	0.38-1.37
Nephritis and Nephrosis	2	4.12	0.48	0.06-1.75
Accidents	32	46.32	0.69	0.47-0.98
Motor Vehicle Accidents	19	22.08	0.86	0.52-1.34
All Other Accidents	13	24.24	0.54	0.29-0.92
Violence	17	22.45	0.76	0.44-1.21
Suicides	13	18.23	0.71	0.38-1.22
Homicides	4	4.22	0.95	0.26-2.42

Table 4. Cause specific deaths and standardized mortality ratios for selected causes of death for Cottage Grove employees ever employed in jobs with definite PFOA exposure.

Cause	Observed	Expected	SMR	95% CI
All Deaths	46	50.14	0.92	0.67-1.22
Cancers				
All Malignant Neoplasms	11	13.79	0.80	0.40-1.43
Buccal Cavity and Pharynx	0	0.31	0.00	0.00-11.81
Digestive Organs and Peritoneum	3	3.44	0.87	0.18-2.55
Esophagus	0	0.42	0.00	0.00-8.86
Stomach	0	0.42	0.00	0.00-8.85
Large Intestine	2	1.20	1.67	0.20-6.02
Rectum	0	0.26	0.00	0.00-13.97
Biliary Passages and Liver Primary	0	0.30	0.00	0.00-12.12
Pancreas	1	0.75	1.34	0.03-7.42
All Other Digestive	0	0.09	0.00	0.00-40.54
Respiratory System	5	4.45	1.12	0.36-2.63
Larynx	0	0.13	0.00	0.00-27.97
Bronchus, Trachea, Lung	5	4.26	1.17	0.38-2.74
Breast	0	0.18	0.00	0.00-20.31
Female Reproductive	0	0.09	0.00	0.00-40.65
Male Reproductive	1	0.85	1.17	0.03-6.51
Prostate	1	0.77	1.30	0.03-7.20
Testis and Other Male Genital Organs	0	0.08	0.00	0.00-45.03
Urinary Organs	0	0.71	0.00	0.00-5.22
Kidney	0	0.47	0.00	0.00-7.82
Bladder and Other Urinary Organs	0	0.23	0.00	0.00-15.72
Malignant Melanoma of Skin	0	0.30	0.00	0.00-12.27
All Lymphatic and Hematopoietic Tissue	0	1.70	0.00	0.00-2.17
Non-malignant causes				
Cerebrovascular Disease	5	1.94	2.58	0.84-6.03
All Heart Disease	17	15.69	1.08	0.63-1.73
Nonmalignant Respiratory Disease	1	2.57	0.39	0.01-2.16
Cirrhosis of Liver	0	1.18	0.00	0.00-3.14
Nephritis and Nephrosis	0	0.23	0.00	0.00-16.01
Accidents	5	4.79	1.04	0.34-2.44
Motor Vehicle Accidents	2	2.43	0.82	0.10-2.97
All Other Accidents	3	2.35	1.28	0.26-3.73
Violence	6	2.64	2.27	0.83-4.95
Suicides	5	2.14	2.33	0.76-5.45
Homicides	1	0.49	2.02	0.05-11.23

Table 5. Cause specific deaths and standardized mortality ratios for selected causes of death for Cottage Grove employees ever employed in jobs with probable PFOA exposure, but did not hold jobs with definite PFOA exposure.

Cause	Observed	Expected	SMR	95% CI
All Deaths	267	314.73	0.85	0.75-0.96
Cancers				
All Malignant Neoplasms	80	90.13	0.89	0.70-1.10
Buccal Cavity and Pharynx	1	1.85	0.54	0.01-3.00
Digestive Organs and Peritoneum	19	22.46	0.85	0.51-1.32
Esophagus	1	2.40	0.42	0.01-2.32
Stomach	1	2.78	0.36	0.01-2.00
Large Intestine	8	8.11	0.99	0.43-1.94
Rectum	2	1.74	1.15	0.14-4.15
Biliary Passages and Liver Primary	1	1.99	0.50	0.01-2.80
Pancreas	6	4.84	1.24	0.45-2.70
All Other Digestive	0	0.61	0.00	0.00-6.00
Respiratory System	26	27.45	0.95	0.62-1.39
Larynx	1	0.80	1.25	0.03-6.93
Bronchus, Trachea, Lung	25	26.36	0.95	0.61-1.40
Breast	2	3.58	0.56	0.07-2.02
Female Reproductive	2	2.22	0.90	0.11-3.26
Male Reproductive	6	6.15	0.98	0.36-2.12
Prostate	5	5.78	0.86	0.28-2.02
Testis and Other Male Genital Organs	1	0.36	2.75	0.07-15.30
Urinary Organs	3	4.38	0.68	0.14-2.00
Kidney	2	2.70	0.74	0.09-2.67
Bladder and Other Urinary Organs	1	1.68	0.59	0.02-3.30
Malignant Melanoma of Skin	2	1.41	1.42	0.17-5.11
All Lymphatic and Hematopoietic Tissue	8	10.34	0.77	0.33-1.52
Non-malignant causes				
Cerebrovascular Disease	10	15.70	0.64	0.30-1.17
All Heart Disease	81	104.04	0.78	0.62-0.97
Nonmalignant Respiratory Disease	12	20.17	0.60	0.31-1.04
Cirrhosis of Liver	6	6.35	0.95	0.35-2.06
Nephritis and Nephrosis	1	1.79	0.56	0.01-3.10
Accidents	16	19.87	0.81	0.46-1.31
Motor Vehicle Accidents	12	9.39	1.28	0.66-2.23
All Other Accidents	4	10.48	0.38	0.10-0.98
Violence	6	9.55	0.63	0.23-1.37
Suicides	6	7.77	0.77	0.28-1.68
Homicides	0	1.78	0.00	0.00-2.07

Table 6. Cause specific deaths and standardized mortality ratios for selected causes of death for Cottage Grove employees never exposed to PFOA or other fluorochemicals (non-chemical division).

Cause	Observed	Expected	SMR	95% CI
All Deaths	294	342.46	0.86	0.76-0.96
Cancers				
All Malignant Neoplasms	81	98.17	0.83	0.66-1.03
Buccal Cavity and Pharynx	1	1.96	0.51	0.01-2.83
Digestive Organs and Peritoneum	20	24.05	0.83	0.51-1.28
Esophagus	2	2.49	0.80	0.10-2.90
Stomach	3	3.04	0.99	0.20-2.88
Large Intestine	9	8.74	1.03	0.47-1.96
Rectum	0	1.88	0.00	0.00-1.96
Biliary Passages and Liver Primary	0	2.11	0.00	0.00-1.75
Pancreas	5	5.12	0.98	0.32-2.28
All Other Digestive	1	0.67	1.49	0.04-8.26
Respiratory System	25	29.18	0.86	0.55-1.27
Larynx	1	0.85	1.18	0.03-6.53
Bronchus, Trachea, Lung	23	28.01	0.82	0.52-1.23
Breast	4	4.70	0.85	0.23-2.18
Female Reproductive	1	2.81	0.36	0.01-1.98
Male Reproductive	2	7.19	0.28	0.03-1.00
Prostate	2	6.82	0.29	0.04-1.06
Testis and Other Male Genital Organs	0	0.36	0.00	0.00-10.12
Urinary Organs	5	4.73	1.06	0.34-2.47
Kidney	1	2.84	0.35	0.01-1.96
Bladder and Other Urinary Organs	4	1.89	2.11	0.58-5.40
Malignant Melanoma of Skin	2	1.48	1.35	0.16-4.89
All Lymphatic and Hematopoietic Tissue	10	11.10	0.90	0.43-1.66
Non-malignant causes				
Cerebrovascular Disease	11	18.21	0.60	0.30-1.08
All Heart Disease	103	114.39	0.90	0.73-1.09
Nonmalignant Respiratory Disease	17	23.11	0.74	0.43-1.18
Cirrhosis of Liver	6	6.74	0.89	0.32-1.94
Nephritis and Nephrosis	1	2.10	0.48	0.01-2.64
Accidents	17	20.71	0.82	0.48-1.31
Motor Vehicle Accidents	10	9.64	1.04	0.50-1.91
All Other Accidents	7	11.07	0.63	0.25-1.30
Violence	6	9.87	0.61	0.22-1.32
Suicides	2	8.04	0.25	0.03-0.90
Homicides	4	1.83	2.19	0.60-5.60

Table 7. Cause specific standardized mortality ratios for Cottage Grove employees with a minimum of one year of employment in a job with definite PFOA exposure.

Cause	Observed	Expected	SMR	95% CI
All Deaths	17	22.25	0.76	0.44-1.22
Cancers				
All Malignant Neoplasms	4	6.33	0.63	0.17-1.62
Digestive Organs and Peritoneum	1	1.59	0.63	0.02-3.48
Esophagus	0	0.20	0.00	0.00-18.87
Stomach	0	0.19	0.00	0.00-19.33
Large Intestine	1	0.56	1.79	0.05-9.94
Rectum	0	0.12	0.00	0.00-30.22
Biliary Passages and Liver Primary	0	0.14	0.00	0.00-26.38
Pancreas	0	0.35	0.00	0.00-10.67
All Other Digestive	0	0.04	0.00	0.00-89.75
Respiratory System	1	2.09	0.48	0.01-2.66
Bronchus, Trachea, Lung	1	2.01	0.50	0.01-2.77
All Other Respiratory	0	0.02	0.00	0.00-160.98
Breast	0	0.07	0.00	0.00-51.86
Prostate	1	0.38	2.63	0.07-14.62
Urinary Organs	0	0.32	0.00	0.00-11.39
Kidney	0	0.21	0.00	0.00-17.37
Bladder and Other Urinary Organs	0	0.11	0.00	0.00-33.12
Malignant Melanoma of Skin	0	0.12	0.00	0.00-29.99
Thyroid and Other Endocrine Glands	0	0.02	0.00	0.00-155.50
All Lymphatic and Hematopoietic Tissue	0	0.75	0.00	0.00-4.90
Non-malignant causes				
Cerebrovascular Disease	3	0.89	3.36	0.69-9.82
All Heart Disease	7	7.28	0.96	0.39-1.98
Other Nonmalignant Respiratory	0	0.70	0.00	0.00-5.30
Cirrhosis of Liver	0	0.52	0.00	0.00-7.11
Accidents	1	1.74	0.58	0.01-3.20
Motor Vehicle Accidents	0	0.84	0.00	0.00-4.41
All Other Accidents	1	0.90	1.11	0.03-6.19
Violence	2	0.93	2.15	0.26-7.75
Suicides	2	0.76	2.62	0.32-9.45
Homicides	0	0.17	0.00	0.00-22.07

Table 8. Cause specific standardized mortality ratios for Cottage Grove employees with a minimum of one year of employment in a job with definite or probable PFOA[a].

Cause	Observed	Expected	SMR	95% CI
All Deaths	219	274.36	0.80	0.70-0.91
Cancers				
All Malignant Neoplasms	68	77.33	0.88	0.68-1.11
Digestive Organs and Peritoneum	21	19.40	1.08	0.67-1.65
Esophagus	1	2.16	0.46	0.01-2.57
Stomach	1	2.42	0.41	0.01-2.29
Large Intestine	10	6.91	1.45	0.69-2.66
Rectum	2	1.51	1.32	0.16-4.78
Biliary Passages and Liver Primary	1	1.70	0.59	0.01-3.27
Pancreas	6	4.17	1.44	0.53-3.13
All Other Digestive	0	0.52	0.00	0.00-7.06
Respiratory System	23	24.20	0.95	0.60-1.43
Bronchus, Trachea, Lung	22	23.22	0.95	0.59-1.43
Breast	0	2.09	0.00	0.00-1.77
Prostate	6	5.19	1.16	0.42-2.52
Urinary Organs	2	3.88	0.52	0.06-1.86
Kidney	1	2.41	0.42	0.01-2.31
Bladder and Other Urinary Organs	1	1.47	0.68	0.02-3.79
Malignant Melanoma of Skin	2	1.30	1.54	0.19-5.55
Thyroid and Other Endocrine Glands	0	0.28	0.00	0.00-13.34
All Lymphatic and Hematopoietic Tissue	4	9.03	0.44	0.12-1.13
Nonmalignant causes				
Cerebrovascular Disease	11	13.03	0.84	0.42-1.51
All Heart Disease	68	90.90	0.75	0.58-0.95
Nonmalignant Respiratory Disease	6	17.09	0.35	0.13-0.76
Cirrhosis of Liver	4	5.69	0.70	0.19-1.80
Accidents	13	18.75	0.69	0.37-1.19
Motor Vehicle Accidents	10	8.95	1.12	0.53-2.06
All Other Accidents	3	9.80	0.31	0.06-0.90
Violence	7	9.35	0.75	0.30-1.54
Suicides	7	7.62	0.92	0.37-1.89
Homicides	0	1.74	0.00	0.00-2.13

a: Includes workers who accrued one year of exposure with definite and probable jobs combined.

Table 9. Observed and expected deaths from cerebrovascular disease with SMRs and 95% CI by years of employment in jobs with definite PFOA exposure.

Years of PFOA Exposure	OBS	EXP	SMR	95% CI
< 1	2	1.05	1.91	0.22-6.91
1-<5	0	0.46	0.00	0.0-8.02
5-<10	3	0.19	15.03	3.02-43.91
• 10	0	0.23	0.0	0.0-15.17
Total	5	1.94	2.58	0.83-6.03

Table 10. Observed and expected deaths from cerebrovascular disease with SMRs and 95% CI by cumulative exposure.

Weighted Exposure[a]	OBS	EXP	SMR	95% CI
>0-2499	8	9.67	0.83	0.36-1.63
2500-4999	2	2.80	0.71	0.08-2.58
5000-7499	1	2.32	0.43	0.01-2.40
7500-9999	0	1.76	0.00	0-2.08
10000-& Over	4	1.21	3.31	0.89-8.46
Total	15	17.75	0.85	0.47-1.39

a: Duration of employment (days)*exposure weighting factor.